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Description

Control Valve for a Hydraulic Brake Booster

BACKGROUND OF INVENTION

[0001] This invention relates to a control valve for a hydraulic brake booster having a shuttle member with a first end to control metering of pressurized fluid to an actuation chamber during a brake application and a second end to control metering of pressurized fluid from the actuation chamber to a reservoir on termination the brake application.

[0002] In hydraulic brake boosters of a type disclosed in U.S. Patent 4,281,585; 4,539,892; 4,625,515; 6,561,596 and U.S. Application No. 10/307,791 filed December 02, 2002, a control valve is located in a first bore and a power piston is located in a second bore of a housing. A lever arrangement is connected to the power piston and the control valve. An input force applied to a brake pedal by an operator acts on the lever arrangement to develop a

manual mode and a power assist mode of operation. The lever arrangement pivots on the power piston and communicates an actuation force that moves the control valve to regulate the flow of pressurize fluid from a source to an operational chamber. The regulated pressurized fluid supplied to the operational chamber acts on the power piston in the first bore to develop an operational force that pressurizes fluid that is supplied to wheel brakes to effect a corresponding brake application. A reaction force produced by regulated pressurized fluid in the movement of the power piston is transmitted back to the brake pedal to balance the input force such that the operational force supplied to move the power piston in the first bore is a function of the input force applied to the brake pedal.

[0003] Additional features such as traction control, dynamic operational control and anti-skid control under the control of an ECU have been added to hydraulic brake booster to provide a total brake system. During an ECU generated brake application, the brake pedal of the hydraulic booster may mirror the movement of the power piston. In addition, as a result of the rapid opening and closing of the control valve during a ECU generated brake application, an increase in the level of noise created as pressur-

ized fluid flows to the actuation chamber and on released from the brake chamber may occur. Structure to hold a brake pedal stationary during an ECU generated brake application is disclosed in U.S. Patent 6,203,119 wherein a control valve seat moves to meter pressurized fluid; in U.S. Patent Application No. 10/307,791 where a separate piston is provided to act on the control valve to meter pressurized fluid; and in U.S. Application 10/767,300 wherein a sleeve acts on the control valve to meter pressurized fluid to effect a brake application but it would not appear that the creation of noise has been specifically addressed in the known prior art.

SUMMARY OF INVENTION

[0004] A advantage of the present invention resides in a control valve for a brake booster in a brake system having a shuttle member with a stem on a first end that controls the metering of pressurized fluid from a source to an actuation chamber during a brake application and a second end with an annular projection that controls metering of pressurized fluid from the actuation chamber to a reservoir on terminate the brake application such that fluid only flows in a same direction and as a result oscillation of the shuttle is attenuated and the noise level of the operation of

the brake booster is reduced.

[0005] According to this invention, the brake booster has a housing with a first bore therein for retaining a power piston, a second bore therein for retaining the control valve and an actuation chamber. The control valve sequentially connects a source of pressurized fluid to the actuation chamber and a reservoir in response to an input force from an actuation arrangement. The pressurized fluid available from the source presented to the actuation chamber acts on the power piston to effect a brake application. On termination of the input force the shuttle valve controls communication of the pressurized fluid present in the actuation chamber to the reservoir. The control valve is characterized by a first cylindrical body that is located in the second bore and having a first stepped axial bore that extends from a first end to a second end. The stepped bore has a first diameter section adjacent the first end that is separated from a second diameter section by an orifice and a shoulder that separates the second diameter section from a third diameter section that extends from the second end. The first diameter section is connected to the source of pressurized fluid while a first radial bore in the first cylindrical body connects the second diameter

section with the actuation chamber and a second radial bore in the first cylindrical body connects the third diameter with the reservoir. A ball located in the first diameter section of the first cylindrical body is urged by a first spring toward a seat adjacent the orifice to define a supply chamber for pressurized fluid within the second bore. A shuttle member that is retained in the second diameter section of the first cylindrical body has a stem on a first end that is located near the orifice and an annular projection on a second end that extends into the third diameter section of the first cylindrical body. A seal carried by the shuttle member prevents fluid communication between the second diameter and second diameter section of the first cylindrical body. A power piston that is retained in a bearing-spacer has an annular flange on a first end located in the third diameter section of the first cylindrical body and a second end that extends into the actuation chamber. The power piston has a second stepped bore that extends from the first end to the second end such that the third diameter section of the first cylindrical body is connected to the actuation chamber. A second spring that is located in the first stepped axial bore urges the second end of the shuttle member toward a first stop

within the second bore to define a position of rest for the shuttle member. A third spring that is located between the second end of the shuttle member and the first end of the power piston urges the annular flange toward a second stop to define a position of rest for the power piston. With the shuttle member and power piston in rest positions, the actuation chamber may freely communicate with the reservoir by way of the second stepped axial bore, third diameter section and second radial bore in the first cylindrical body. An input force applied by actuation arrangement acts on the second end of the power piston and after overcoming the force the third spring moves the annular flange into engagement with the annular projection on the shuttle member to terminate communication to the reservoir through the second axial bore and thereafter overcoming the force of the second spring moves the stem into engagement with the ball and finally after overcoming the force of the first spring moves the ball off the seat to allow metered pressurized fluid to flow through the orifice and be communicated to the actuation chamber by way of the second diameter and first radial bore to effect a brake application. On the said input force being removed from the second end of the second cylindrical

member, the first spring moves the ball into engagement with the seat to termination communication of pressurized fluid through the orifice while the third spring moves the flange away from the annular projection on the shuttle member to meter the flow of pressurized fluid present in the actuation chamber to the reservoir by way of the second axial bore in the second cylindrical member, the third diameter and second radial bore in the first cylindrical member. Since the shuttle member is sealed in the second diameter section of the first cylindrical body, the flow of fluid between the orifice and the second radial bore only occurs along a flow path defined by the first radial bore, actuation chamber and second stepped bore and as a result of the shape of the stem and annular projection the oscillation of the shuttle member is does not oscillate within the second diameter to create noise during the operation of the brake booster.

[0006] An advantage of this invention resides in a shuttle member for a control valve having a stem on a first end and an annular projection whereby pressurized fluid is first metered on being presented to an actuation chamber and second metered on be released from the actuation chamber to a reservoir to such that movement of the shuttle

member is substantially linear.

[0007] A further advantage of this invention resides in a shuttle member for a control valve wherein an end of a stem has an annular shape that transitions into a conical shape such that the flow of pressurized fluid from a source through an orifice is essentially a function of the conical shape and increased with the movement of the conical shape into the orifice.

Brief Description of Drawings

[0008] Figure 1 is a schematic illustration of a brake system that includes a hydraulic brake booster with a shuttle member made according to the principals of the present invention;

[0009] Figure 2 is a sectional view of the hydraulic brake booster for use in the brake system of Figure 1;

[0010] Figure 3 is an enlarged sectional view of the control valve of Figure 2 illustrating the shuttle member in a position of rest;

[0011] Figure 4 is an enlarged sectional view of the stem of shuttle member for the control valve of Figure 3;

[0012] Figure 5 is an enlarged sectional view of the annular projection of shuttle member of Figure 3;

[0013] Figure 6 is a sectional view of the hydraulic brake booster of Figure 2 wherein the shuttle member is in an actuation

position in response to an input force being applied to an actuation arrangement by an operator to effect a brake application;

[0014] Figure 7 is an enlarged sectional view of the control valve of Figure 6;

[0015] Figure 8 is an enlarged sectional view of the stem of the shuttle member of Figure 7;

[0016] Figure 9 is an enlarged sectional view of the annular projection of the shuttle valve of Figure 7;

[0017] Figure 10 is a sectional view of the control valve of Figure 2 showing a relationship between the components of the shuttle member during movement between a position of rest and an actuation position; and

[0018] Figure 11 is a sectional view of the annular projection shuttle member during actuation of the control valve through an input supplied under the control of an ECU.

DETAILED DESCRIPTION

[0019] The brake system 10 as shown in Figure 1 and details of the components thereof shown in Figures 2-11, includes a hydraulic brake booster 12 for supplying a master cylinder 13 wherein an operational force derived from pressurized fluid is supplied to a first set of wheel brakes 14,14" by a first conduit 16 and to a second set of wheel brakes

18,18" by a second conduit 20 to effect a brake application. The hydraulic brake booster 12, which is commonly referred to as a closed center booster, receives pressurized supply fluid a source, either directly from a pump 24 or an accumulator 22 that is charged and maintained to a predetermined fluid pressure level by pump 24.

[0020] The brake booster 12 may function in several modes of operation including a manual mode, a boost mode, a boost plus manual mode all of which are under the control of an operator or an electronic mode that is under the control of an ECU 40. In the manual mode, a brake force from an operator is transmitted directly from the brake pedal 28 directly acts on the pistons in the master cylinder 13, in a boost mode pressurized fluid under the control of a control valve 60 is supplied to an actuator chamber that acts on a piston in the master cylinder 13, in the boost plus manual mode, once hydraulic run out is reached a manual input is added to the output force developed from the pressurized fluid of the boost mode to effect a brake application and in the electronic mode the ECU activates first 37 and second 39 solenoid valves to sequentially terminate communication between an actuation chamber 80 and a reservoir 108 to initiate communi-

cation of pressurized fluid that acts on the control valve 60 to meter pressurized fluid from a source that is simultaneously supplied to an actuation chambers 80 and 80'. In the electronic mode, the pressurized fluid supplied to the actuation chamber 80 is restricted and acts on the power piston 50 to initiate the development of an output force while the pressurized fluid in the actuation chamber 80' acts on the control valve 60 to metered pressurized fluid that acts on power piston 50 to develop an output force that corresponds to a braking force derived by the ECU 40 to meet desired operational activities of a vehicle.

[0021] In the manual or first mode, the development of a hydraulic actuation force in brake booster 12 is under the control of an operator. The operator applies a brake force to the brake pedal 28 to develop a corresponding desired braking event, and this brake force is communicated through a lever arrangement 200 to activate the control valve 60. When activated, the control valve 60 initially moves as illustrated in Figure 10 to a position as illustrated in Figure 6 to meters pressurized fluid that is supplied to the actuation chamber 80 for the development a corresponding actuation force on the power piston 50 to move pistons in the master cylinder 13 and pressurized

fluid that is supplied to operate wheel brakes 14,14" and wheel brakes 18,18" to effect a brake application. On termination of the brake force by the operator to brake pedal 28, the components of the brake booster 12 are returned to a rest state as illustrated in Figures 2, 3 and 4.

[0022] In the electronic mode, the brake system 10 is under the control of the ECU 40. The ECU is connected to the following components in the brake system: a build solenoid valve 15; a decay solenoid valve 15"; and a wheel speed sensor 17 for each wheel in the first set of wheel brakes 14,14" and second set of wheel brakes 18,18". Each of the wheel speed sensors 17 provide the electronic control unit (ECU) 40 with an input signal relating to a current functional operational of a particular wheel of the vehicle and are evaluated other inputs and data relating to the vehicle including but not limited to: the operation of the motor pump; the pressure of the pressurized supply fluid; dynamic forces experienced by the vehicle; accumulator fluid supply pressure, the level of fluid in a reservoir and etc. that may effect the safe operation of the vehicle and the ability of achieving a desired braking application. If the ECU 40 determines after evaluating the inputs relating to the operational features or conditions currently experi-

enced by the vehicle that a less than optimum operation situation is occurring or forthcoming, the ECU 40 is programmed to institute independent braking of the wheel brakes 14, 14" and 18,18" by transmitting an operating signal that closes normally opened solenoid valve 37 to reservoir 108 and open normally closed solenoid valve 39. When solenoid valve 39 is opened pressurized hydraulic fluid flows from the accumulator 22 and to activate actuation piston 92 and directly activate the control valve 60 of the hydraulic brake booster 12 and at the same time a restricted quantity of pressurized fluid flows to actuation chamber 80. Once control valve 60 is activated, as illustrated in Figure 11, pressurized hydraulic fluid is communicated to actuation chamber 80 and acts on the power piston 50 to create an operational force that in turn acts on pistons in the master cylinder 13 to produce pressurized fluid that is supplied to individually activate the wheel brakes 14, 14" and 18,18" in accordance with signals from the ECU 40 to effect a brake application and attenuate the less than optimum operating condition which could effect the safe operation of the vehicle.

[0023] The details of hydraulic brake booster 12 is best illustrated in Figures 2-11 and with the exception of control

valve 60 is similar to the structure disclosed in U. S. Patent Application 10/307,791. The brake booster includes a housing 100 with a power piston 50 that is sealingly retained in a first bore 102 and a control valve 60 that is sealingly retained in a second bore 104, an input member 30 piloted in power piston 50 and linked to the control valve 60 by the lever arrangement 200. In the boost or first mode, the lever arrangement 200 is responsive to a braking input force that is communicated from a brake pedal 28 to the input member 30 for moving the control valve 60 that meters pressurized fluid from a source, either pump 24 or accumulator 22. The metered pressurized fluid is communicated to a actuation chamber 80 in housing 100 and acts on the power piston 50 to develop a hydraulic actuation force that in turn acts on piston in the master cylinder 13 to pressurize fluid therein that is communicated to the wheel brakes wheel brakes 14, 14" and 18,18" in a brake system 10 for effecting a corresponding brake application.

[0024] In more particular detail, the housing 100 includes a first inlet port 106 connected to supply conduit 21 for receiving pressurized hydraulic fluid either directly from pump 24 or from accumulator 22; a relief port 110 connected to

a common reservoir 108 for pump 24 and master cylinder 13 and a second inlet port 112 that is connected to supply conduit 21 by conduit 23 through a normally closed solenoid valve 39 under the control of ECU 40 or a normally opened solenoid valve 37 connected to the common reservoir 108. The housing 100 has a stepped first bore 102 that extends clear through the housing 100, a stepped second bore 104 that is parallel with the first bore 102 and extends into the housing 100 from a first side until it intersects with a cross bore 105 that extends from the actuation chamber 80. Housing 100 has a first groove 106a through which first inlet 106 is connected to the second bore 104, a second groove 111 through which the second bore 104 is connected to the reservoir 108 and a third groove 82 through which the second bore 104 is connected by passage 83 to the actuation chamber 80 and a fourth groove 113 through which passage 112 is selectively connected to reservoir 108 and the source of pressurized fluid under the control of the ECU 40.

[0025] The control valve 60, see Figures 3,4 and 5 includes a first cylindrical body 62 and a second cylindrical body 64 that are sealingly located the second bore 104. An end plug 79 that is fastened by being screwed into housing 100 holds

the second cylindrical body 64 against a shoulder 101 in the housing 100 to correspondingly align radial bores or passages 58,58"...58^n that extend from a stepped bore 65 in the first cylindrical body 62 with groove 106a and inlet port 106, with groove 82 and passage 83 to actuation chamber 80, with groove 111 and relief port 110 connected with reservoir 108 and radial bore 74 that extends from the stepped axial bore 67 in the second cylindrical body 64 with groove 113 to passage 112 connected with the circuitry controlled by the ECU 40. The stepped bore 65 includes at least a first diameter 65a, a second diameter 65b and a third diameter 65c. The first diameter 65a extends from a first end 71 to an orifice 54 located between the first diameter 65a and the second diameter 65b while a shoulder 73 separates the second diameter 65b from the third diameter 65c that extends from a second end 75. Radial bore 58 is located in the first diameter 65a, radial bore 58' is located in the second diameter 65b while radial bore 58^n is located in the third diameter 65c. With the second cylindrical body 64 against shoulder 101, an actuation chamber 80' is defined within the second cylindrical body 64 by the radial bore 74. The first cylindrical body 62 is further distinguished in that radial bore

or passage 58' connects the second diameter 65b with passage 83 connected to actuation chamber 80 and radial passage 58^{N} connects the third diameter 65c with reservoir 108.

[0026] The control valve 60 further includes a shuttle member 66, see Figures 3,4 and 5 that is sealingly retained in the second diameter 65b of bore 65 of the first cylindrical body 62. Shuttle member 66 has an integral axial stem 68 on a first end 81a that functions as a needle valve within the stepped bore 65 of the first cylindrical body 62 and an annular projection 72 located on a second end 81b that extends into the third diameter area 65c of the first cylindrical body 62. The shuttle member 66 is a solid cylindrical member that includes a rib 70 that is located between the first end 81a and the second end 81b and a seal 70a that is carried by the cylindrical body 66. The seal 70a engages the second diameter 65b and prevents direct communication of fluid that flow through the orifice 54 from flowing to the third diameter 65c area of the cylindrical body 62. The annular projection 72 is defined by a conical entry surface 72a that transitions into a cylinder surface 72b adjacent to a bearing and sealing surface 72c.

[0027] A ball 52, see Figures 3 and 4, is located in the first diam-

eter 65a of the stepped bore 65 and is urged toward a seat 55 that surrounds orifice 54 by a spring 56. The volume within the first cylindrical body 62 bounded by seat 55, radial passage 58, groove 106a and the first diameter 65a defines a supply chamber 54a for pressurized fluid available from the source through conduit 21. The volume within the first cylindrical body 62 bounded by the second diameter 65b, orifice 54, face of the shuttle member 66 and stem 68 radial bore 58' defines an operational chamber 85 that is connected to actuation chamber 80 by passage 83.

[0028] The orifice 54 has a shape, as best-illustrated in Figures 3 and 4, that is matched with the stem 68 on the first end 81a of the shuttle member 66. The stem 68 has an annular cylindrical surface 68a that extends from the first end 81a to a transition point of a conical surface 68b such that the flow of pressurized fluid through the orifice 54 is smooth and increases as a function of the movement of the shuttle member 66 toward the orifice 54.

[0029] The second cylindrical body 64, see Figures 3 and 5, is sealingly located in the second bore 104 with a first end 84 located in the third diameter 65c of the first cylindrical body 62 and a second end 85 that extends into the actua-

tion chamber 80. The first end 84 extends into the second bore 104 a distance established by the engagement of shoulder 84a with shoulder 101 to set the alignment of radial bores or passages 58,58"...58^n with ports 106 and 110 and radial bore passage 74 with port 112. The stepped bore 67 has a first diameter 67a and a second diameter 67b such that an actuation sleeve 89 is concentrically located in the first diameter 67a has an inner diameter 89a that is matched with the second diameter 67b to define a uniform diameter for receiving an actuation piston 92. The sleeve 89 has a flange 90 that engages a shoulder 64a on the second cylindrical body 64 such that an end 90a is located in the secondary actuation chamber 80' formed therein.

[0030] A spacer 91 defined by a sleeve is located in the third diameter 65c of the first cylindrical body 62 between rib 70 on shuttle member 66 and the end of the second cylindrical body 64 located in the second bore 104 to define a stop for shuttle member 66 within the first cylindrical body 62.

[0031] The control valve 66 is further defined by an actuation piston 92 that has a cylindrical body with first end having a flange 94 thereon that is located within the third diame-

ter 65c of the first cylindrical body 62 and a second end 61 that is located in the actuation chamber 80. The cylindrical body is concentric to an axial bore defined by the diameter 89a of sleeve 89 and diameter 67b of the second cylindrical body 64. The cylindrical body has a stepped bore 96 therein that extends from the flange 94 on the first end to the second end 61 that provides a flow path between the actuation chamber 80 and the area bounded by the third diameter bore 65c of the first cylindrical body 62.

[0032] A return spring 76 that is located in the second diameter area 65b of the first cylindrical body 62 acts on the shuttle member 66 to urge rib 70 against spacer 91 to position the second end 81b of the shuttle member 66 at a specific distance from shoulder 101 to define a rest position for the shuttle member 66. At the same time a return spring 77 that is located between the second end 81b of the shuttle member 66 and actuation piston 92 urges the flange 94 toward and into engagement with a stop provided by flange 90 and shoulder 64a to define a position of rest for the actuation piston 92.

[0033] When the shuttle member 66 and actuation piston 92 are located in a position of rest as best illustrated in Figures

2, 3, 4 and 5, a flow path is established between the stepped bore 96 and reservoir 108 by a space relationship of flange 94 and the conical surface 72a on projection 72 on end 81b of the shuttle member 66 such that actuation chamber 80 is freely connected to the reservoir 108.

[0034] The power piston 50 as illustrated in Figure 2 and 6 is sealingly located in the first bore 102 and urged toward a rest position in the actuation chamber 80 by a return spring 48. A bracket 32 that straddles a projection 152 that extend from the power piston is retained thereon by a pin 33 that passes through an axial slot 313 in a shaft 302 on the input member 30.

[0035] The input member 30 as described in U.S. Patent Application 10/307,791 includes; a cylindrical body 300 that is sealingly located in the first bore 102; a shaft 302 that is connected to push rod 29 by way of the cylindrical body 300 that is located in bore 306 within the power piston 50; a first spring 304 that is concentric to the shaft 302; a bracket 32 that is carried on shaft 302; a second or return spring 306 that acts on shaft 302 to urges the cylindrical body 300 toward a position of rest; and a ball valve assembly 308.

[0036] The bracket 32 has a general rectangular shaped base

with an axial bore 34 for receiving shaft 302 and a radial opening 35 that is retained in perpendicular plane with respect to projection 152 by a pin 33 that extends though a slot 313 in shaft 302. Bracket 32 is capable of axial movement on shaft 302 through which an input force is applied to the end 208 of lever 202 in lever arrangement 200 along a radial plane with respect to the axis of the first bore 102. When a threaded second end of shaft 302 is screwed into cylindrical body 300, spring 304 is compressed and as a result spring 304 provides a force that urges bracket 32 toward and into engagement with head 310.

[0037] The lever arrangement 200 includes a first lever 202 and a second lever 222 made up parallel arms, (only one is shown). The first lever 202 has a first end 204 that is pivotally secured in housing 100 by a first pivot pin 206 and a second end 208 with a semi-spherical surface thereon that is located in the radial opening 35 of bracket 32. The parallel arms of the second lever 222 each have a first end 224 and a second end with the first pin 206 passing through an elongated oval slot 225 in the first end 224 and the second end being aligned with the end face 51 on the power piston 50. The second lever 222 is connected

to the first lever 202 by a second pivot pin 228 that sequentially extends through a first arm of the second lever 222, first lever 202 and a second arm of the second lever 222 at a fulcrum point 230 on the first lever 202. The first end 224 of the parallel arms of the second lever 222 have a cam surface 232 that engages face 61 on actuation piston 92 for the control valve 60 at a point contact while the second end of the parallel arms 222 have an arcuate surface that define a point contact with the end face 51 of operational power piston 50 such that return spring 306 transmits a force through bracket 32 to end 208 of the first lever 202 to hold the cam surface 232 against face 61 and hold the arcuate surface on the second end of lever 222 against the end face 51 on the power piston 50. The fulcrum point 230 on the first lever 202 is selected such that as first lever 202 pivots in an arc about pivot pin 206, an actuation force that is applied to the second lever 222 is balanced between the first end 224 and the second end that engages the power piston 50.

[0038] The lever arrangement 200 has a first length defined by a distance between the first pin 206 and the second end 208 on the first lever 202 and a second length defined by a distance between the first pin 206 and the second end

of the second lever 222 that engages the power piston 50 such that the axial movement of the cylindrical body 300 and the power piston 50 is defined by a ratio of the first length to the second length. Thus, a hydraulic output force developed by metered pressurized fluid presented to the actuation chamber 80 by way of the control valve is proportional to an input force applied to brake pedal 28.

[0039] The brake booster 12 is designed to include a hydraulic actuator arrangement 400 that is under the control of the ECU 40 to achieve an independent electronic mode of operation. Hydraulic actuator arrangement 400, see Figure 11, includes sleeve 89 that surrounds actuation piston 92 of the control valve 66. Sleeve 89 has a flange or lip 90 that engages shoulder 64a on the second cylindrical member 64 to position a second end 90a thereon in actuation chamber 80' defined by the second cylindrical member 64 within the second bore 104. The hydraulic actuator 400 further includes a restrictive orifice or bleed 410 that is located in conduit 27 that is connected to lead 23 through which solenoid valve 39 is connected to passage 112 and a one-way check valve 412 located between the orifice 410 and a port 416 in access port cap 418 for chamber 80 in housing 100, see Figure 1. With the one-

way check valve 412 in conduit 27 communication of fluid pressure between actuation chamber 80 and reservoir 108 is inhibited and as a result functional operation in an electronic mode is strictly under the control of ECU 40.

Operation of the Brake Booster

[0040] For a given vehicle, the operational force developed by an input force applied to a brake booster to meet operational braking parameters is effected by several factors including weight of the vehicle, size of the power piston in the brake booster and the available hydraulic fluid pressure developed by a source. Only after the parameters have been defined are the component parts that make up a brake system selected. For instance in a brake system equipped with a hydraulic brake booster 12, a gain or ratio is selected to define a relationship between the input force applied to the brake pedal 28 by an operator and the operational force developed by metering pressurized fluid to the actuation chamber 80 to act on a power piston 50. In the lever arrangement 200 for brake booster 12, the location of the fulcrum point 230 on the first lever 202 is selected such a balanced force is applied to the first 224 and second ends of the second lever 222 and in activating the control valve 60 to meter pressurized fluid

to the actuation chamber 80. In this brake booster 12, the resulting hydraulic force applied to the power piston 50 is proportional to the input force applied by an operator to the input member 30 to effect a brake application.

[0041] In more detail, when an operator desires to effect a brake application in a vehicle having a hydraulic brake booster 12 as shown in Figure 2, an input force applied to brake pedal 28 that is communicated through input push rod 29 to move input member 30 that includes the cylindrical body 300, head 310 on stem 302 and bracket 32 all of which move in a direction toward power piston 50. Movement of the bracket 32 causes that end 208 of lever 202 to pivot about pin 206 and impart an actuation force through pin 228 at fulcrum 230. The actuation force at pin 228 is applied through the arms of the second lever 222 such that half of the actuation force is applied to end or face 61 on actuation piston 92 by way of cam surface 232 and the other half is applied to the end face 51 of the power piston 50 through the second end of the second lever 222. The actuation force applied to actuation piston 92 after overcoming return spring 77 moves flange 94 toward the conical surface 72a and into engagement with cylindrical surface 72b to terminate communication be-

tween axial bore 96 and the reservoir 108 as illustrated in Figures 9 and 10 and with further movement flange 94 engages bearing surface 72c and after overcoming the force of return spring 76 moves the shuttle member 66 such that end 81 on stem 68 engages ball 52 and after overcoming the force of spring 56 moves ball 52 away from seat 55 as illustrated in Figures 6,7 and 8 such that pressurized fluid flows from chamber 54a through orifice 54 into the operational chamber 85 within the second diameter area 65b of the first cylindrical body 64 and out radial bore 58' to actuation chamber 80 by way of passage 83 . The metered pressurized supply fluid presented to chamber 80 acts on the second end 51 of piston 50 to create an operational force that is communicated through output push rod 11 to act on pistons in the master cylinder 13 and correspondingly pressurize fluid therein that is supplied through conduits 16 and 20 to effect a brake application in wheel brakes 14,14" and 18,18". The flow of the pressurized fluid through the orifice 54 is defined by a space relationship between the cylindrical surface on stem and the conical surface on stem 68 such that metered pressurized fluid flow through the orifice 54 increases as a linear function of the movement of shuttle member 66

in response to an input force applied to the actuation piston 92. Depending on the application, this linear function could be modified by changing the length of the cylindrical surface 68a and/or the pitch of the conical surface 68b. On termination of the input force to brake pedal 28, the component are returned to a position of rest as shown in Figures 2 and 3 such that actuation chamber 80 is in free communication with reservoir 108.In returning the control valve 60 to the position of rest, the input force on end 61 of the actuation piston 92 is removed and spring 56 acts to move ball 52 against seat 55 to terminate the flow of pressurized fluid through orifice 54. With ball 52 on seat 55, the fluid pressure differential across shuttle member 66 is now essentially equal and as a result return spring 77 moves flange 94 into engagement with a stop defined by flange 89 and shoulder 64a to open communication between flange 94 and the annular projection 72 on the second end 81b of the shuttle member 66. The fluid pressure in the actuation chamber 80 is reduced by flow of fluid to reservoir 108 causing the pressure differential across the shuttle member 66 to be correspondingly reduced such that return spring 76 may now rib 70 toward and into engagement with a stop defined by spacer

87 and the first end of the second cylindrical member 64 as illustrated in Figure 3 and 5 such that chamber 80 is in free communication with reservoir 108. The flow of fluid from actuation chamber 80 is under the control of the end 81b of the shuttle member and is metered by the space relationship between the conical surface 72a on the annular projection 72 and as a result flow occurs in a manner such that oscillation of the shuttle member 66 is essentially non-existent and any noise resulting from the flow of fluid to the reservoir 108 is minimal and does not add to the operational noise of the hydraulic brake system.

[0042] The control valve 60 functions in the following manner. When hydraulic run out for brake booster 12 occurs, shuttle member 66 will have moved ball 52 completely away from seat 55 and the apex 68a of conical surface will be aligned with the orifice 54 as rib 70 engages shoulder on the first cylindrical body 62. When rib 70 engages shoulder, the lever arrangement 200 is aligned such that bracket 34 separates from head 310. In this situation, further operational output force may be achieved through an input force applied to cylindrical body 300 as the input force is directly transferred into power piston 50 and added to the output force produced by the pressurized

fluid in actuation chamber 80 to produce an output force based on boost mode plus manual mode.

[0043] In event that the pressurized fluid from the supply is unavailable, the brake booster 12 is under a manual control mode. An input force that is applied to brake pedal 28 can be used to pressurize the pistons in master cylinder 13. An input force applied to input member 30 moves the cylindrical member 300 and bracket 32 associated therewith such that end 208 of lever 202 pivots on pin 206 and imparts an actuation force through pin 228 to the second lever 222 to activate the control valve 60. As in a power assist, the actuation force is communicated through cam surface 232 into end 61 of the actuation piston 92 and the actuation piston 92 moves to initially close relief port 110 by seating flange 94 on cylindrical surface 72b and bearing surface 72c and when flange 94 engages bearing surface 72c the shuttle member 66 moves such the stem 68 moves ball 52 off of seat 55 to prevent a hydraulic lock that would be adverse to movement of the power piston 50 within bore 102. Since no pressurized supply fluid is available, the input force on input member 30 continues to move cylindrical member 300 and shaft 302 toward power piston 50 and eventually the first lever 202 en-

gages housing 100 such that the bracket 34 thereafter remains stationary and head 310 separates from bracket 34 compress spring 321 and engage power piston 50 to define a direct link between the power piston 50 and input member 30 such that the input force applied to pedal 28 is communicated to push rod 11 to pressurize fluid in the master cylinder 13 to effect a brake application.

[0044] The hydraulic booster 12 for the brake system 10 may also be activated through an electronic mode under the control of the ECU 40. The ECU 40 has a capability to independently effect a brake application should inputs from the various sensors relating to the operation of the vehicle indicate that a brake application should be performed to meet or maintain desired operating condition for a vehicle. The ECU 40 initiates the electronic mode by the ECU 40 supplying signals that sequentially close the normally opened solenoid valve 39 and open the normally closed solenoid valve 37 as shown in Figure 1, such that supply fluid available in conduit 21 is communicated to actuation chamber 80' through passage 112 and to actuation 80 through conduit 27 by way of restricted orifice 410 and one-way check valve 412 to port 416 and port 112. The restricted pressurized fluid communicated through re-

stricted orifice 410 to actuation chamber 80 immediately increases the fluid pressure level in chamber 80 to the restricted fluid pressure level and acts on the power piston 50 to initiate a brake application while at the same time the full level of the pressurized fluid communicated to the actuation chamber 80' acts on the second end 90a of sleeve 89 to move the flange 90 off of shoulder 64a and move flange 94 toward the annular projection 72 to restrict the flow of fluid with respect to conical surface 72a and finally into a sealing engagement with cylindrical surface 72b to interrupt communication from axial bore 96 to the reservoir 108, as illustrated in Figure 11. As the fluid pressure continues to build in actuation chamber 80' the shuttle member 66 moves toward ball 52 such that stem 68 eventually moves ball off seat 55 to permit metered pressurized fluid to be communicated to chamber 80 by way of passage 83 as illustrated in Figures 6 and 8 to effect a brake application. The metered pressurized supply fluid in chamber 80 is added to the pressurize level of the restricted pressurized fluid therein to act on the second end 51 of piston 50 to create an operational force that is communicated through output push rod 11 to act on pistons in the master cylinder 13 and corre-

spondingly pressurize fluid therein that is supplied through conduits 16 and 20 to effect an independent second brake application in wheel brakes 14,14" and 18,18".

[0045] When the ECU 40 determines a reduction in the fluid pressure in the actuation chamber 80 is desirable to meet a change in operational characteristics, a signal is supplied to maintain solenoid valve 39 in an opened condition while a pulsed signal is supplied to solenoid valve 37 in a selectively allow pressurized fluid supplied to the actuation chamber 80' to be communicated to reservoir 108, as illustrated in Figures 2 and 3.

[0046] The hydraulic brake booster 10 is distinguished in that the flow of pressurized fluid presented to inlet port 106 that is metered by control valve 60 as it passes through the orifice 54 before being presented to actuation chamber 80 through passage 83 and returned to the reservoir 108 by flowing through axial bore 96 before being metered by the restriction formed between annular projection 72 on shuttle member 66 and flange 94 in flowing to relief port 110 is always in a same direction and as a result the creation of noise by such flow is essentially non existent.